Notes on the Delivery of Deuterium and Gold Ions for RHIC

C.J. Gardner

March 1, 2002

On day one, the plan is to have deuterium delivered from one Tandem and gold delivered from the other. Eventually we may have gold and deuterium sources feeding into the same Tandem. One would then pulse a steering magnet to direct either deuterium or gold ions into the Tandem. In this case the Tandem terminal voltage would have to be switched between 14 MV for gold and 6 MV for deuterium. (This would require a few minutes.)

The magnets of the TTB line will have to be switched between two different rigidities for gold and deuteron transport. Some time ago, when either gold or iron was being delivered to Booster for the physics program, a test was done in which the TTB magnets were switched to a different rigidity and then back to the original rigidity after a prescribed hysteresis loop. Upon restoration of the original rigidity, the accelerated beam intensity in Booster returned to its previous level. Computer code has been written (by Ahovi Kponou) to carry out the switching procedure. (This has not yet been tested with beam.) The fields in the large bends of the line are monitored with NMR probes and do not in fact return to exactly the same values after switching to a different rigidity and then back. To get back to the same probe reading, a slight adjustment in the current has to be made. This is currently done but hand, but could be automated by closing the feedback loop between NMR probe and magnet power supply.

Table 1 lists Tandem terminal voltage V_t, magnetic rigidity $B\rho$, and Booster Inflector voltage V_I for ions with various kinetic energies W. The rows with the ion name in **bold** print contain the nominal parameter values. In order to keep the deuteron fault levels in the TTB line below the allowed limit, the kinetic energy is to be limited to $W = 12.00/2$ MeV per nucleon as per the RSC. Note that in order for deuterons to have the same rigidity as the gold ions in the TTB line, the deuteron kinetic energy

Table 1: Tandem Voltage, TTB Rigidity, and Inflector Voltage

Ion	V_t (MV)	W (MeV/n)	$B\rho$ (Tm)	V_I (KV)
Gold	14.014	182.12/197	0.852334	22.127
Deut	8.600	17.3255/2	0.852333	67.081
Deut	7.937	16.00/2	0.818936	61.971
Deut	6.937	14.00/2	0.765841	54.253
Deut	5.937	12.00/2	0.708843	46.527
Deut	4.936	10.00/2	0.646910	38.793
Deut	3.936	8.00/2	0.578460	31.051
Deut	2.936	6.00/2	0.500828	23.300
Deut	1.936	4.00/2	0.408815	15.542

would have to be 17.3255/2 MeV per nucleon.

According to D. Steski, the pulsed deuteron current from the D^- source typically would be 100 μA but could go as high as 300 μA. Transmission through the Tandem could be as low as 50%. So the current in the TTB line would be between 50 and 150 μA. For deuterons with $W = 6$ MeV/n kinetic energy at Booster injection, the revolution period is 5.9786 μs. Since experience has shown that no more than 45 turns can fit into the Booster acceptance, the maximum pulse width that can be accepted by Booster is then 270 μs. Assuming a pulsed current of 100 μA in the TTB line, one then has 1.7×10^{11} deuterons available per Tandem pulse at Booster injection. Booster output/input is typically 50% or less. The maximum intensity available for one RHIC bunch would then be 8.4×10^{10} deuterons.

The maximum current allowed in the TTB line is the equivalent of 200 nA of DC beam. A satisfactory radiation safety device which will interlock the beam if this limit is exceeded, is still in the design phase. A scheme involving two interlocking chipmunks which would monitor the radiation from an inserted multiwire profile monitor is being considered.

Table 2 lists the gold and deuteron parameters at Booster injection and extraction, and at AGS injection. (Note that a proton with 200 MeV kinetic energy has rigidity $B\rho = 2.149636$ Tm.) The plan is to inject deuterons and gold into AGS at the same rigidity.

Table 3 lists the gold and deuteron parameters at AGS extraction and at RHIC injection, transition, and store. The plan is to inject deuterons and

Table 2: Booster Injection and Extraction; AGS Injection

Machine	Q	W (MeV/n)	β	hf (MHz)	$B\rho$ (Tm)	Ion
Booster	32	182.13/197	0.04452620	0.396923	0.852334	**Gold**
Injection	1	17.3255/2	0.13498753	1.203330	0.852333	Deut
$h = 6$	1	12.0/2	0.11257912	1.003573	0.708843	**Deut**
Booster	32	101.1721	0.43172485	3.848558	9.152950	**Gold**
Extraction	1	153.3764	0.51123622	4.557353	3.721589	**Deut**
$h = 6$	1	115.5512	0.45537048	4.059344	3.200000	Deut
AGS	77	97.0596	0.42412821	3.780839	3.721589	**Gold**
Injection	1	153.3764	0.51123622	4.557353	3.721589	**Deut**
$h = 24$	1	115.5512	0.45537048	4.059344	3.200000	Deut

gold into RHIC at the same rigidity. The nominal store energy for gold ions is 100 GeV per nucleon; deuterons at store must have the same revolution frequency as the gold ions. For reference we list the various ion masses in **Table 4**.

Fault studies have been carried out to determine radiation levels due to loss of deuterium beam in the TTB line. As a result, soil was added to the berm at various locations. A further study needs to be done to determine the levels where the road goes over the berm.

Table 3: AGS Extraction; RHIC Injection, Transition, and Store

Machine	Q	E (GeV/n)	γ	hf (MHz)	$B\rho$ (Tm)	Ion
AGS Extraction	77	9.796016	10.520480	4.437007	83.221098	**Gold**
$h = 12$	1	12.194763	13.003498	4.443989	81.113782	**Deut**
RHIC Injection	79	9.795961	10.520480	28.023205	81.113782	**Gold**
$h = 360$	1	12.194763	13.003498	28.067300	81.113782	**Deut**
RHIC Transition	79	21.313625	22.89	28.123788	177.117274	**Gold**
$h = 360$	1	21.466388	22.89	28.123788	143.071598	**Deut**
RHIC Store	79	100.000000	107.396090	197.046110	831.763013	**Gold**
$h = 2520$	1	100.716738	107.396090	197.046110	671.880622	**Deut**

Table 4: Ion Masses

Ion	Q	Mass (GeV/c^2)
Gold	32	183.4568120
Gold	77	183.4341440
Gold	79	183.4331220
Deut	1	1.875612762